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May, 1970

INTRODUCTION

This document comprises the final semi-annual report to be prepared under the University of Florida's NASA Institutional Grant, NGL-10-005-005, which will be phased out on October 31, 1970. A final annual report will be prepared and submitted in November.

As usual, the individual project reports have been written by the 15 principal investigators, and edited and assembled under the supervision of the Chairman of the University of Florida NASA Steering Committee. The table on the following page summarizes the history of the Grant since its inception in 1964.

In reading the project reports, one can scarcely avoid a feeling of amazement at the continuing volume of research being produced under budgets that have shrunk to the point where most can only be described as minuscule. As the Summary of Publications (p.34) indicates, a total of 12 journal publications has resulted during the report period. Since the total expenditures during this period were only \$25,446, this means that the average cost per paper was \$2,100. This figure may be contrasted with others with which the editor of this document happens to be familiar. In his own field, a relatively inexpensive branch of radio astronomy, the mean cost per paper over many years has been about \$10,000. The cost per paper of research produced last year at the National Radio Astronomy Observatory was \$70,000. To cite a somewhat more extreme example, the cost per paper of the rocket aeronomy/astronomy program conducted at Kitt Peak National Observatory is approximately \$500,000. Doubtless one could find even more costly fields, such as space astronomy or high-energy physics.

The explanation of the above paradox is of course that the work on the Institutional Grant projects is continuing under the impetus of momentum acquired during a period of more adequate funding. However, no system is frictionless, and in the absence of new inputs of energy (funds), this momentum will inexorably die away. Traditionally, the universities have provided the foundation of all science, and there is no evidence, even on the horizon, of a viable alternative to this system. Also; under the current tax structure there is unfortunately no evidence of a viable alternative to Federal funding of modern university science. Thus, unless there is a marked reversal of current trends, Federal science administrators now in office are presiding over the death of the United States as a major scientific power--which in the present technological age will lead rather rapidly to the death of the nation as a major power.

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TABLE I: HISTORY OF PROJECTS UNDER THE NASA INSTITUTIONAL GRANT

*PROJECT	DEPARTMENT	INVESTIGATOR	PROJECT DESCRIPTION	BUDGETS (INCLUDING OVERHEAD)						
				1964	1964-65	1965-66	1966-67	1967-68	1968-69	1969-70
A01	Astronomy	A. G. Smith	Study of 20 Mc Signal of Satellite	\$ 7,185	\$ 5,125	Compl.	--	--	--	--
A02	Astronomy	T. D. Carr	Use of Arecibo Radio Telescope	6,974	10,875	\$ 10,050	\$ 10,000	Compl.	--	--
A03	Astronomy	A. G. Smith	Low Frequency Jovian Radio Spectrum	34,435	34,625	38,562	26,000	Compl.	--	--
A04	Aerospace	D. T. Williams	Plastic Mirrors	10,200	2,000	Term.	--	--	--	--
A05	Physics	F. E. Dunnam	Nuclear Astrophysics	26,500	33,100	25,600	14,000	--	--	--
A06	Aerospace	M. H. Clarkson	Magnetofluidmechanics	52,000	62,000	50,000	25,000	\$ 12,400	\$ 18,000	9,000
A07	Aerospace	K. Millsaps	Electric Boundary Layers	17,600	17,600	**	--	--	--	--
A08	Eng. Mech.	W. A. Nash	Behavior of Inflatable Structures	15,350	15,625	Compl.	--	--	--	--
A09	Eng. Mech.	J. Sickmann	Fluids in Low Gravitational Fields	9,700	10,690	15,012	11,000	Compl.	--	--
A10	Metallurgy	F. N. Rhines	High Temperature Oxidation	6,500	8,375	9,175	9,170	Compl.	--	--
A11	Metallurgy	R. Reed-Hill	Fracture of Hf-Zr Alloys	8,800	9,925	Compl.	--	--	--	--
A12	Metallurgy	R. Reed-Hill	Low Temperature Fracture of Mg	7,000	8,175	Compl.	--	--	--	--
A13	Physics	A. A. Broyles	Fluid States of Matter	26,500	26,875	18,000	7,200	7,300	--	--
A14	Mathematics	R. Selfridge	Computational Forms for Functions	14,200	Term.	--	--	--	--	--
A15	Chemistry	E. Muschitz	Molecular Beam Investigations	32,825	37,500	16,250	16,000	4,800	--	--
A16	Physics	T. L. Bailey	Collisions of Electrons & Molecules	17,500	22,500	24,600	20,000	12,100	--	--
A17	Nuclear Eng.	R. E. Uhrig	Nuclear Propulsion	27,800	26,700	27,800	--	--	--	--
A18	Physics	A. E. S. Green	Radiation in Planetary Atmospheres	12,500	Compl.	--	--	--	--	--
A19	Astronomy	K.-Y. Chen	Photometry of Variable Stars	--	8,700	8,688	4,800	6,100	6,240	5,500
A20	Chemistry	J. Winefordner	Flame and Arc Spectrophotometry	--	13,000	**	--	--	--	--
A21	Physics	A. E. S. Green	Theoretical Nuclear Physics	--	1,500	**	--	--	--	--
A22	Aerospace	K. Millsaps	Hydrothermodynamics of Jets	--	5,129	14,075	18,280	11,400	--	--
A23	Radiology	H. L. Cromroy	Hyperbaric Oxygen and Aging	--	--	22,000	13,690	6,900	6,960	2,300
A24	Aerospace	O. E. Myers	Experiments on Color Vision	--	--	6,100	14,000	7,800	10,200	5,000
A25	Chem. Eng.	R. W. Falten	Turbulent Diffusion of Heat & Mass	--	--	14,375	15,000	9,000	--	--
A26	Elec. Eng.	A. P. Sage	Nonlinear Dynamic Processes	--	--	12,675	12,500	Compl.	--	--
A27	Chemistry	S. O. Colgate	Scattering in Molecular Beams	--	--	20,000	19,000	11,200	--	--
A28	Astronomy	G. C. Omer	Astronomical Study of Gravity	--	--	8,013	8,160	5,800	12,000	6,000
A29	Aerospace	B. M. Leadon	Gasdynamics of Strong Shock Waves	--	--	--	20,000	12,500	5,760	3,000
A30	Chemistry	G. H. Myers	Reactions of Excited Atoms and Molecules	--	--	--	12,600	9,600	15,600	8,500
A31	Eng. Mech.	J. Sickmann	Pulsating Incompressible Liquids	--	--	--	11,000	Compl.	9,600	4,500
A32	Metallurgy	R. Reed-Hill	Deformation in Ti at Low Temperature	--	--	--	10,390	7,400	--	--
A33	Physiology	A. B. Otis	Ventilatory Effect of Phonation	--	--	--	3,720	3,800	5,640	3,000
A34	Physics	C. F. Hooper	Spectral Line Broadening in Plasmas	--	--	--	15,000	11,200	12,000	6,000
A35	Physics	R. C. Isler	Excited States of Atmospheric Gases	--	--	--	11,200	9,000	9,000	4,500
A36	Psychology	W. B. Webb	Comparative Study of Sleep Patterns	--	--	--	7,020	5,300	5,400	--
A37	Management	J. H. James	Research Spin-Off to Fla. Industry	--	--	--	13,400	10,700	--	--
A38	Myrm/Soclogy	Iuraka/W.A. Hill	Evaluation of Scientists' Performance	--	--	--	--	--	13,920	7,875
A39	Aerospace	M. H. Clarkson	Scientist's Role in Societal Problems	--	--	--	--	--	1,200	--
A41	Physiology	M. J. Fregly	Metabolic Response to Hyperbaric O ₂	--	--	--	--	5,000	8,040	4,000
A42	Chemistry	N. Y. Ohm	Wave Functions of Excited States	--	--	--	--	6,500	--	--
A43	Chemistry	Wm. Weltner	High Temperature Molecules	--	--	--	--	6,400	--	--
A44	Elec. Eng.	J. Salz	Space Communications by Phase-Lock	--	--	--	--	10,000	--	--
A46	Mech. Eng.	R. K. Irey	Heat Transfer to Liquid Helium II	--	--	--	--	6,700	--	--
A47	Metallurgy	F. N. Rhines	Rupture in Dilute Uranium Alloys	--	--	--	--	5,800	--	--
A52	Psychiatry	G. W. Barnard	Cardiovascular Responses to Stress	--	--	--	--	5,400	5,400	3,000
A53	Astronomy	A. Smith/Carr	Major Radioastronomical Array	--	--	--	--	15,900	15,000	11,000
TOTALS				\$333,569	\$360,019	\$340,975	\$348,130	\$226,000	\$159,960	\$ 83,175

* Gaps in the numbering scheme exist because cutback in funding forced cancellation of originally scheduled projects.

** Funded by AFOSR

PROJECT A06
MAGNETOFLUIDMECHANICS

1. Department: Aerospace Engineering

2. Principal Investigator: M. H. Clarkson

3. Background: This project has been involved with the analysis and diagnostics of inductive electrodeless discharges operating in atmospheric gases at pressures from several millitorr to atmospheric. Analyses have been performed for both the low-pressure discharge and the thermal arc. Electrostatic probes and spectrographic data obtained in active discharges in argon have demonstrated the validity of the theoretical calculations. Present work is directed toward the development of the discharge for applications in lasers and high-pressure gas heaters and light sources. Support for the research in high-pressure electrodeless arcs has been assumed by Arnold Engineering Development Center. This project has supported three doctoral dissertations and eleven masters theses.

The research has resulted in the publication of five papers in the scientific journals. Five papers have been presented at national scientific meetings.

4. Progress from November 1, 1969 through April 30, 1970:

a. Low-Density Electrodeless Discharge

Spectroscopic measurements have been made on a flowing two-gas vortex-stabilized electrodeless discharge in argon and nitrogen. The rotational temperature was determined to be 1200°K. From initial measurements it does not appear that a stable separation of the two gases is obtained. More detailed spectroscopic measurements must be made to determine the degree of separation obtained.

b. Angular Flux Distribution from an Orifice:

Experimental measurements have been completed and the apparatus disassembled. The results are contained in a paper to be submitted to the Journal of Fluid Mechanics.

c. High-Pressure Electrodeless Discharges

This research is being continued under sponsorship of AEDC. Experiments will be performed at pressures to 10 atmospheres to determine suitability for their use as high-enthalpy heaters for wind tunnels.

5. Publications:

A paper entitled, "The Electromagnetic Field in the Electrodeless Discharge," has been submitted for publication.

6. Expenditures from November 1, 1969 through April 30, 1970:

Salaries	\$1,683.25
Expense	<u>984.74</u>
Total Expenditures	\$2,667.99

PROJECT A19

PHOTOMETRIC INVESTIGATIONS OF STELLAR ATMOSPHERES

1. Department: Physics & Astronomy
2. Principal Investigator: Kwan-Yu Chen
3. Background: A study of variable stars has been pursued and is now being continued in this program. In the past, photoelectric observations of selected stars have been made using the 12.5-inch Newtonian telescope at the University of Florida, the 16-inch telescopes at Kitt Peak National Observatory and Cerro Tololo Inter-American Observatory, and the University of Florida 30-inch telescope at the Rosemary Hill Observatory. Reduction and analysis of observational data is carried out with the aid of the IBM 360/65 computer on the campus. In addition, theoretical and computational work on problems of close binary stars has been done in an effort to improve the analyses of light curves.
4. Progress from November 1, 1960 through April 30, 1970: The solution of the light curves of V701 Centauri was re-examined and critically reviewed. The solution in which a "third light," L_3 , is introduced in order to fit the rectified light curves, is a possible one; but unless the existence of the third component in this system is actually confirmed by spectroscopic observations, it would remain only a hypothetical possibility. During this report period, work has been done on rectifications of the observed light curves, based on Russell's generalized model in addition to the idealized model used in the previous investigation, and on the analysis of these rectified light curves. The solutions essentially fall in two classes: one with L_3 and one without. The summary of the results is as follows:

	<u>With L_3</u>	<u>Without L_3</u>
Radius of smaller star relative to larger	0.8	0.6
Radius of larger star relative to distance between stars	0.40	0.45
Inclination of orbit to celestial sphere	84°	74°
Fraction of light of the larger star	0.45	0.83
Fraction of light of the small star	0.16	0.17
Fraction of light of the third light	0.39	- -

The photometric analysis of this star is finally being concluded.

Photoelectric observations of BV 442 and BV 449 have been made, using the 30-inch telescope at the Rosemary Hill Observatory.

A paper entitled "Study of Eclipsing Binary Stars using the Jacobian Integral," was presented at the Thirty-Fourth Annual Meeting of the Florida Academy of Sciences on March 6, 1970.

5. Publications:

Chen, Kwan-Yu, and Nibondh Saibejra. "The Main Sequence Eclipsing Binaries and the Restricted Problem of Three Bodies," Bull. Am. Phys. Soc. 11, 15, 202 (1970).

6. Expenditures from November 1, 1969 through 30 April 1970: No major expenditures have yet been made since funds are being reserved for the summer months.

PROJECT A23

HYPERBARIC OXYGEN AND RADIOSENSITIVITY

1. Department: Radiology and Entomology
2. Principal Investigator: H. L. Cromroy
3. Background: It had been established in the field of radiation biology that oxygen concentration in a living system at the time of irradiation strongly influenced the obtained response. For example, when the bacterium Escherichia coli is irradiated in a thoroughly oxygenated atmosphere versus a pure nitrogen atmosphere, there is a change in radiosensitivity, with the oxygenated bacteria being three times more sensitive than those in nitrogen at the same exposure doses.¹ This and other known effects of oxygen formed the basis for the project research, which considered the physiologic effects of hypoxic and hybaroxic conditions produced within a confined area, as well as the possible modification of these effects when combined with another physical insult such as ionizing radiation.
4. Progress from November 1, 1969 through April 30, 1970: The experimental research on erythropoietin, started in January, 1969, has been completed and a summary of the research follows:

Androgenic hormones have been reported to increase erythropoiesis by direct stimulation of erythroid marrow. Because androgens also possess a renotrophic effect, the contribution of renal mass to erthropoietin production was investigated.

Rats were injected for 6 weeks with Depotestosterone (in cotton seed oil), prior to and after nephrectomy. Controls received cotton seed oil or were sham-operated. Endogenous erythropoietin production was suppressed during the experiment by transfusion with packed red blood cells. Erythropoietin production was stimulated by subjecting the animals to hypoxia for 19 hours. Kidneys were then removed and blood obtained for erythropoietin bioassay.

Hypoxia resulted in variable increases in erythropoietin levels in all animals. This variation in erythropoietin production was found to correlate closely with the relative renal mass (renal weight: body weight ratio), with erythropoietin levels increasing proportionately to renal mass either in animals receiving testosterone or in controls. Animals not subjected to hypoxia did not show any increase in erythropoietin levels, despite administration of androgens and resultant increase in renal mass.

¹ H. L. Cromroy and H. I. Adler, 1962. "Influence of β -Mercaptoethylamine and Oxygen Removal on the X-Ray Sensitivity of Four Strains of Escherichia Coli." J. Gen. Microbiology 28, 431-435.

These studies show that the enhanced production of erythropoietin by androgens during hypoxia is due not only to its direct action on bone marrow, but also to the renotrophic effect of the steroid.

Our second project has been the study of the effects of two physical insults on mammals in confined areas. We have been submitting chinese hamsters to low levels of ozone and ionizing radiation while they are in the hyperbaric chamber and then culturing the peripheral leucocytes to examine them for chromosomal aberrations. We are in process of analyzing the data. But it does appear that ozone is a very effective mutagenic agent even at level of 0.2 ppm.

5. Publications:

J. A. Soler, W. D. Noyes, H. L. Cromroy, and G. A. Richard, "The Contribution of Relative Renal Mass to Erythropoietin Production," Paper presented on May 2, 1970 at the Special Sessions of the American Pediatric Society/Society for Pediatric Research, Atlantic City, N. J.

R. E. Zelac and H. L. Cromroy, 1970. "Variation of Rat Radiosensitivity with Increased Oxygen Partial Pressure of Inspired Gas." Health Physics 18, 227-231.

6. Expenditures from November 1, 1969 through April 30, 1970:

Expense	<u>\$457.55</u>
Total Expenditures	\$457.55

PROJECT A24

MECHANISM OF COLOR VISION

1. Department: Aerospace Engineering
2. Principal Investigator: O. E. Myers
3. Background: The purpose of this study has been to determine the extent to which spectral information might be processed prior to the physical absorption of light by the chromophore of the photo-pigment of the receptor cells of the vertebrate retina. The physical processes include the establishment of an image upon the retina, hence chromatic aberration; scattering in pre-retinal media; and the effects of dispersion, non-uniformities, and interactions among the elements of the fiber-optics mosaic of rods and cones.

Characterization of these processes can be accomplished without resort to oil-immersion and electron microscopy by modeling at longer wavelengths, because physical length scales directly as the wavelength, provided refractive indices are unchanged. With K-Band microwaves, dimensions become centimeters rather than microns.

4. Progress from November 1, 1969 through April 30, 1970: Mathematics: The computer program for determination of the propagatory modes in concentric cylindrical dielectric waveguides is now functional, and the current effort is to determine to what extent this system can be compared with the simple dielectric waveguide. Two approaches are being evaluated: a large cylinder with the weighted effect of an annular aperture, which seems promising of straightforward characterization; and a small cylinder with the weighted refractive index of the surround, which would seem to be more useful.

The analysis is being prepared in final form for publication.

Experimental: Toward verification of earlier measurements, the scanning probe is being modified to improve its stability and linearity. This was deemed essential because of poor signal-to-noise ratios in the preliminary work. Polyethylene tubing does not have sufficient rigidity for service in this study; and the available material, lucite, has significant losses throughout the K-Band.

In an attempt to understand the differences between rod and cone function, their metabolism has been studied by comparing protein production in normal and dystrophic rats (a rod retina) with that of the squirrel citellus tridecemlineatus (a cone retina) by radio-autograph studies. This study is not completed, but amino acid uptake (photopigment production is inferred) is diffuse in the cone, markedly in contrast with rod behavior.

5. Publications:

Herron, W. L., Riegel, B. W., Myers, O. E., and Rubin, M. L. "Retinal Dystrophy in the Rat - a Pigment Epithelial Disease," Invest. Ophth. 8, 595 (1969).

6. Expenditures from November 1, 1969 through April 30, 1970:

Salaries	\$2,717
Expense	<u>110</u>
Total Expenditures	\$2,827

PROJECT A27

SCATTERING OF ALKALI METALS IN HIGH INTENSITY MOLECULAR BEAMS

1. Department: Chemistry
2. Principal Investigator: S. O. Colgate
3. Background: This program is concerned with inferring the magnitude of the pair-wise intermolecular potential from measurements of the scattering occurring where a beam of alkali atoms traverses a gas-filled region. Total elastic scattering cross sections are measured as functions of the alkali beam energy, which is controlled by mechanical velocity selection.

The method of measuring the total collision cross sections of alkali beams scattered by confined Maxwellian gases has been well established; the principal success, thus far, is the scattering gas density measurement technique developed in this work. With a sensitive thermocouple pressure gauge situated inside the scattering chamber, we have been able to measure scattering gas pressures in the submillitorr range to an apparent accuracy of $\pm 2\%$. Combining this result with other uncertainties in the scattering measurements, we obtain experimental cross sections to an accuracy of about $\pm 5\%$. Such cross sections are of great utility for inferring the actual magnitudes of intermolecular potential energies. Thus far we have velocity dependent data for the systems Cs - He, Cs - Kr, Cs - Xe, K - Ar, and K - Kr.

4. Progress from November 1, 1969 through April 30, 1970: Because the collision energies are low in this experiment, the scattering is dominated by long-range attractive forces. Each of the above systems behaves in reasonable accord with a model based on scattering by a potential of the form $U(r) = -C_6/r^6$, where r is the internuclear separation distance and C_6 is a parameter characteristic of the collision species. Values of the C_6 parameters deduced from the scattering experiments on the above systems agree, within the mutual limits of uncertainty, with theoretical estimates based on polarizabilities of the interacting species.

Now that this technique is established, it is desirable to apply it to enough systems to generate a basic set of potential constants for simple collision pairs. Because an abundance of earlier data obtained in experiments to measure relative scattering cross sections is available, our task is not formidable. It should be sufficient, at present, to measure the absolute cross sections of a few systems selectively chosen to permit ready normalization of the relative values. These experiments have now been completed and the machine has been modified to yield more definitive information about the potential.

During this report period we have installed a new crossed-beam source developed by Dr. Robert Nelson, a postdoctoral fellow, and have made

preliminary tests of this system. The original design, which used a hypodermic needle as the beam source, has been modified to use a metal capillary array, since the needle did not allow sufficient gas flow. The capillary array, composed of 0.002" holes on about 0.0025" centers (40% open area) provides excellent collimation of the crossed beam while allowing sufficient gas flow to give the desired attenuation of the main beam (20%-30%). The use of the cross beam source not only greatly reduces the loss of resolution of the glory undulations caused by the Maxwellian velocity distribution of the scattering gas, but it also speeds up the rate at which measurements can be taken. This increase results from the fact that while the scattering chamber requires several minutes to fill or empty, the cross beam will be run continuously and the direction of the cross beam changes so that it does not impinge upon the main beam when unscattered measurements are being made. For this reason the cross beam is supported upon a "see-saw" arrangement which can be manipulated from outside the vacuum chamber.

In addition to this experimental work, some calculations have been performed during this report period to determine the exact form of the variation of gas density near and in the slits of a scattering chamber. These calculations, which were performed on the IBM 360/65 computer at the University of Florida, were done by Dr. Nelson and Mr. Smith, a graduate student. So far the calculations have confirmed the expectation that the average gas density in a slit of uniform cross section is one-half the density inside the scattering chamber, and work is now in progress to determine how this density varies at all points within the slit, both on and off the beam axis.

5. Publications:

Colgate, S. O and Imeson, T. C., "Scattering of Low Velocity Neutral Particles: The Cs - He, Cs - Kr, and Cs - Xe Interactions," J. Chem. Phys., in press.

6. Expenditures from November 1, 1969 through April 30, 1970:

Expense	\$ 654.70
Capital Equipment	<u>642.50</u>
Total Expenditures	\$1,297.20

PROJECT A28

ASTRONOMICAL INVESTIGATIONS OF THE GRAVITATIONAL FIELD

1. Department: Physics and Astronomy
2. Principal Investigator: Guy C. Omer, Jr.
3. Background: The General Theory of Relativity allows a description of the gravitational field which can depart from that of Newton, particularly at great distances. The controversial cosmological term in Einstein's field equations provides a gravitational effect which would increase with distance. Since the value of this term is extremely small (if not zero), large intergalactic distances must be used if the effect is to be detected.

For the foregoing reasons, clusters of galaxies have been studied for the last few years. A cluster of galaxies is a large-scale gravitating system which might be expected to show departures from strict Newtonian gravitation. A cluster of galaxies is also sufficiently limited to be studied in detail and with some assurance. The cosmological constant is also important to cosmology, but the universe can only be known to us imperfectly and in small part.

4. Progress from November 1, 1969 through April 30, 1970: The extragalactic group at the University of Florida is made up of the Principal Investigator and his graduate students Eugene E. Clark, Robert W. Davis, and Craig F. La Force. We have also collaborated with a radio astronomy group under Prof. T. D. Carr, including his graduate Frank Donovan. The two groups have made a combined radio and optical study of the Coma and Hercules clusters of galaxies. The Coma cluster is almost the classic type of regular, condensed, cluster made up predominately of elliptical galaxies. The Hercules cluster is of the opposite type, being irregular in form and consisting mainly of spiral galaxies. It was hoped to reach some conclusions about the existence of intergalactic matter from a comparison of the radio isophotes of equal radiated energy and the optical isophotes of equal counts of galaxies. At the present time, the decision is not clear-cut. The radio noise could come from an intergalactic medium, or it could originate in several discrete radio sources spread over the clusters.

Mr. E. E. Clark is completing his Ph.D. thesis this term. He has successfully investigated the theoretical optical effects of a large cluster of galaxies. Such a cluster would act as a convergent gravitational lens. Mr. Clark finds that galaxies seen behind a large cluster might be brightened by as much as 1.5. This result has important cosmological consequences. Sandage, assuming that the distant galaxies are not brightened, has concluded that the universe is oscillating with a rather short time-scale and a very high average density of matter. If the galaxies have been brightened by the optical effect predicted by Mr. Clark, then the form of the red-shift vs. distance relationship is changed, since the galaxies would now be at greater distances. The

changed state of affairs would allow for a monotonically expanding universe with a long time-scale and a much lower average density of matter. Mr. Clark has also found other optical effects, such as a displacement of the image or an aberration of the image, which might be used to fix upper limits to the total mass of the cluster of galaxies. Mr. Clark intends to continue this important work next year at King's College in London, where he has accepted a post-doctoral appointment.

While the cluster model used by Mr. Clark was of constant density, Mr. Robert W. Davis is calculating the more difficult non-homogeneous models for clusters of galaxies. He is fitting his models to the observational data of the Coma cluster of galaxies. The main problems that arise stem from ambiguities in the original distribution, lack of symmetry, and the numerical round-off error. An attack on these problems has been made by applying error theory to a series of best-fitted orthogonal polynomials. This work is still in progress.

Mr. Craig F. La Force has been making a careful optical analysis of the cluster Abell 2256. His work is complete and will comprise his M.S. thesis. Really detailed knowledge of the structures of clusters of galaxies is quite scant. One never knows whether a particular cluster, such as Coma, might not be unique. It is necessary to study several clusters to see which details are common to all and which details might be accidental.

5. Publications:

1. F. F. Donovan, Jr., T. D. Carr, and G. C. Omer, Jr., "Radio Mapping of the Hercules Cluster of Galaxies," Bull. Am. Astron. Soc. 2, 190, (1970).

2. C. F. La Force, "The Cluster of Galaxies Abell 2256," Bull. Am. Phys. Soc., 11 15, 202, (1970).

3. R. W. Davis, "Data Reduction for Clusters of Galaxies," Bull. Am. Phys. Soc., 11 15, 202, (1970).

4. F. F. Donovan, Jr., T. D. Carr, G. C. Omer, Jr., "Radio Mapping of the Hercules Cluster of Galaxies," Bull. Am. Phys. Soc., 11 15, 203 (1970).

6. Expenditures from November 1, 1969 through April 30, 1970:

Expense	<u>\$270</u>
Total Expenditures	\$270

PROJECT A29

GASDYNAMICS OF STRONG SHOCK WAVES

1. Department: Aerospace Engineering

2. Principal Investigator: B. M. Leadon

3. Background: The problem, in broad view, is to understand the structure of strong shock waves in various gases and gas mixtures. Many studies have been made of this overall problem, most of them during the past two decades, but few were concerned with precursor ionization mechanisms. Ionization ahead of the shock was observed first in metal shock tubes, later in glass shock tubes, and finally during a spacecraft re-entry as a magnified radar target many times larger than the re-entering body itself. Theoretical calculations based on several proposed ionization or electron diffusion models were unsuccessful in predicting sufficiently high electron densities to account for the measured values until the calculations of S.S.R. Murty in this laboratory. Murty proposed a two-step ionization model in which resonant-line radiation from behind the shock first excited, and then ionized, the gas throughout a large distance ahead of the shock wave. A principal feature of this model is that pressure broadening behind the shock permits photons from the wings of the broadened line profile to penetrate far ahead before being absorbed by the cold, low-pressure gas. Murty's calculations were done for monatomic hydrogen, 4.54×10^6 cm/sec. shock velocity, and a pre-shock number density of 10^{17} cm⁻³.

To test the reality of the two-step model, measurements of the absorption of radiation by the cold gas may be made simultaneously with measurements of electron number densities ahead of the shock wave. Since it is more convenient to work with argon or Xenon than with dissociated hydrogen, Murty's calculations must be repeated, insofar as possible, for those gases.

It has been suggested that a three-step process may provide an easier ionization mechanism than a two-step process. This possibility is regarded as one which should be explored by this project.

Preparations have been made in part for mass spectrometric analysis of the chemical state of gases following strong shock compression.

4. Progress from November 1, 1969 through April 30, 1970: The two-step ionization process studied by Murty has been compared with alternative three-step and one-step processes under the assumption of radiation equilibrium between the gas behind and ahead of the shock in atomic hydrogen. The more detailed process, including absorption of the forward radiation and numerous additional levels of excitation, evidently must be included in this calculation before the value of any particular model can be assessed. This is being done in atomic hydrogen with considerable care. The absorption of u.v. radiation is also being measured experimentally in Xenon by measuring the detailed line profiles of radiation originating behind a shock wave at about $M = 30$.

These two activities preclude the continuation of the mass-spectrometric measurement preparations at the present time.

One M.S. student received his degree in December of 1969, and he presented his thesis in an A.I.A.A. student paper competition in Atlanta on April 23, 1970.

5. Publications:

Ronald S. Brunsvold, "The Design and Construction of a Platinum Film Velocity Gage," M.S. Thesis, University of Florida, December, 1969. (Presented at A.I.A.A. Student Papers Competition, Atlanta, April 23, 1970.)

6. Expenditures from November 1, 1969 through April 30, 1970:

Salaries	\$4,049
Expense	<u>786</u>
Total Expenditures	\$4,835

PROJECT A30

KINETICS OF EXCITED MOLECULES

1. Department: Chemistry
2. Principal Investigator: G.H. Myers
3. Background: The research in progress is concerned with the formation and decay reactions of metastable excited molecular oxygen. We are using a fast flow system with a microwave discharge to produce $O_2(a^1\Delta_g)$ and atomic oxygen. The $b^1\Sigma_g^+$ state of O_2 is formed downstream from the discharge by two $a^1\Delta_g$ molecules disproportionating to yield one $b^1\Sigma_g^+$ and a ground state molecule. The relatively small concentration of $b^1\Sigma_g^+$ obtained is usually a steady state value determined by both the rate of formation from $a^1\Delta_g$ and the rates of homogeneous and surface quenching reactions. Due to the nature of the steady-state kinetics of $b^1\Sigma_g^+$, measurements of the decrease of the optical emission from this state as a quenching gas is introduced yield only the ratio of the homogeneous and wall quenching rate constants, k_Q/k_W . Previous indirect determination of k_W have led to more than a factor of 10 uncertainty in the values of k_Q reported. We have developed a new technique for obtaining k_W and k_Q directly. This involves inserting into the flow a wire spiral which preferentially quenches the $b^1\Sigma_g^+$ state so that a steady-state situation no longer exists. The rate at which the $b^1\Sigma_g^+$ grows back in downstream from this spiral is directly related to $k_W + k_Q [Q]$.
4. Progress from November 1, 1969 through April 30, 1970: Using a HgO film to remove the O atoms produced in the discharge, absolute rate constants for the quenching of $O_2^1\Sigma_g^+$ by a number of quenchers have been obtained. Values of rate constants which have been determined are given in the following Table:

Quencher	H_2O	NH_3	H_2	CO_2	NO	NO_2	N_2	SO_2	Ar	O_2
$k_Q \times 10^{14} \text{ cc sec}^{-1}$	400	200	40	20	4	2.5	0.6	0.3	<0.1	<0.1

A preliminary report on this work, including a brief description of the method and the value of the k_Q for quenching by water, will appear shortly (see Reference a). It is planned to add several other rate constants to this table and to publish a full report shortly.

It has been noted that when NO_2 is added to a flow containing both excited molecular O_2 and O atoms an increase in the O_2^* emission is observed. We are currently attempting to determine the mechanism for this increase. This may

involve a complex mechanism since O atoms are known to react with NO₂. Because of its possible importance as a mechanism for the formation of singlet oxygen in polluted atmospheres, the possibility of energy transfer from NO₂* to O₂ has been explored. However, we have not as yet been able directly to observe this transfer process.

In a separate series of experiments, we have attempted to make optical absorption measurements of NO₂ trapped in a neon matrix at 4°K with the hope of obtaining polarized optical spectra which would be useful in elucidating the electronic structure of NO₂*. Previous ESR measurements have indicated that NO₂ is frozen out with the plane of the molecule preferentially oriented parallel to the surface on which the matrix is formed. Our ESR measurements, taken at much higher resolution, indicate that the NO₂ is trapped in a number of different sites in the matrix. The analyses of our ESR spectra indicate that some NO₂ are indeed oriented planar, but that other NO₂ (in approximately equal concentration) are trapped in sites at which the NO₂ may execute complete or partial rotations about the O---O axis or the C_{2v} symmetry axis. These ESR results are important in helping understand how molecules of the non-linear AB₂ type orient in rare gas matrices, particularly since they challenge the previous assumption that these molecules would always be obtained in fixed (non-rotating) sites. However, the presence of these rotating molecules makes polarized optical spectral studies impossible. A report on these findings will be published shortly (see Reference b).

5. Publications and Papers Presented:

- a. "Quenching of O₂(b¹Σ_g⁺)", G. H. Myers and R. J. O'Brien, Jr., Ann. N. Y. Acad. Sci., in press (1970).
- b. "E.S.R. Spectra of NO₂ in Inert Matrices", G. H. Myers, W. C. Easley, and B. A. Zilles, J. Chem. Phys. 53, No. 3 (in press) (1970).
- c. "Quenching of O₂*", with R. J. O'Brien, Paper PHYS-22, 158th ACS Meeting September, 1969.
- d. "Quenching of O₂(b¹Σ_g⁺)", with R. J. O'Brien, International Conference on Singlet Molecular Oxygen and Its Role in Environmental Sciences, October, 1969.
- e. "Kinetics of O₂* and Other Reactions of Atmospheric Importance", Chemistry Department Seminar, North Carolina State University, January, 1970.
- f. "Fluorescence Quenching and Spectroscopy of NO₂", Invited Paper, 3M Photochemistry Symposium, May, 1970.

6. Expenditures from November 1, 1969 through April 30, 1970:

Salaries	\$ 745.16
Expense	980.95
Capital Equipment	<u>642.20</u>
Total	\$2,368.31

PROJECT A33

VENTILATORY IMPLICATIONS OF PHONATION

1. Department: Physiology
2. Principal Investigator: A. B. Otis
3. Background: Although the primary function of breathing is to serve the respiratory needs of the body, an important secondary function in human beings is the part it plays in the production of sound--especially in speech. In our earlier work we have been concerned with determining to what extent the demands of these two functions may interfere with each other under stressful circumstances. An understanding of this is pertinent to any situation such as space exploration where communication by intelligible speech is required and where at the same time physical exertion may be demanded.
4. Progress from November 1, 1969 through April 30, 1970: Work on this project has been in abeyance for the past few months. We have reserved the small budget for use during the summer months, since more time will be available when teaching demands are minimal.
5. Publications:
No new publications during the report period.
6. Expenditures from November 1, 1969 through April 30, 1970: None

PROJECT A34

A STUDY OF SPECTRAL LINE BROADENING IN PLASMA

1. Department: Physics and Astronomy
2. Principal Investigator: C. F. Hooper, Jr.
3. Background: The shape of the broadened spectral lines emitted or absorbed by neutral and ionized gases is determined primarily by the interparticle forces present in the gas. Consequently, much effort has been devoted to the development of a theory which will accurately predict the shape of these lines. Such a theory would permit the observable characteristics of a given line (shift, width, etc.) to serve as noninterfering probes for a determination of the temperature, density, etc. of the gas. The purpose of the research conducted in this program is to investigate the phenomenon of spectral line broadening in plasmas in a systematic manner which will eventually lead to a general theory capable of predicting complete line profiles in a unified manner (center-wings). Further, all approximations employed have been introduced in such a manner that systematic corrections can easily be made. To date, we have primarily employed the "relaxation theory" to pursue this problem, but we are currently also using Green function techniques; specifically, we are interested in ascertaining the relationship between these approaches and those previously formulated. A refined relaxation theory is being used to calculate Lyman profiles for both He II and H. The intention is to generate a general relaxation theory which is capable of explaining these relatively simple line shapes and which can then be extended to treat more complicated lines, such as those comprising the Balmer series and other non-hydrogenic lines.
4. Progress from November 1, 1969 through April 30, 1970: Research from the preceding six-month period has been continued. Improved line shape calculations for the Lyman- α line of hydrogen have been performed. The techniques developed for the Lyman- α line have been extended to the Lyman- β line. Efforts to include strong and quenching collisions have progressed to the point where the first rough calculations have been performed. Indications are that we will indeed be able to remove the necessity of using strong-collision cutoffs in line-broadening calculations.

The study of the effect of ion motion on line shapes has also reached a point where we have been able to make calculations. Preliminary results indicate that previous line-broadening theories have tended to underestimate the importance of ion motion. Calculations on this problem are being continued.

The phase of the research which has employed Green functions to study the line broadening problem has been completed. A rough draft of a doctoral dissertation based on this effort is currently being reviewed.

Electric microfield distribution functions for a two-component plasma have been determined. These are currently being used in He II line shape calculations.

5. Publications:

Dufty, J. W., "Charge Density Fluctuations in Spectral Line Broadening" Phys. Rev. 187, 305 (1969).

Dufty, J. W., "Ion Motion in Plasma Line Broadening" Phys. Rev. (in press).

Papers Presented:

Lee, R. W., Dufty, J. W., Hooper, C. F. Jr., "A Green's Function Technique for Line Broadening in Plasmas." Bull. Am. Phys. Soc. 15, 170 (1970).

O'Brien, J. T. and Hooper, C. F. Jr., "Electric Microfield Distributions in a Plasma of Singly and Doubly Charged Ions." Bull. Am. Phys. Soc. 15, 171 (1970).

6. Expenditures from November 1, 1969 through April 30, 1970:

Salaries	\$1,520.00
Expense	<u>582.90</u>
Total Expenditures	\$2,102.90

PROJECT A35

COLLISION CROSS SECTIONS AND LIFETIMES OF
EXCITED STATES OF ATMOSPHERIC GASES

1. Department: Physics
2. Principal Investigator: R. C. Isler
3. Background: Two types of experiments are being pursued under the current project:
 1. Level-crossing spectroscopy of atoms and diatomic molecules
 2. Optical excitation in low energy ion-atom and ion-molecule collisions

Experiments in level-crossing spectroscopy are performed by observing the resonance radiation which is scattered by a cell of atoms or molecules as a function of the strength of a magnetic field in which the absorption cell is placed. Two or more atomic levels may be made to approach one another and to cross by varying the strength of the field. The angular distribution of light which is coherently scattered by two or more levels is a function of their separation. If the angle of the exciting and re-radiated beams is 90° , a sweep through the level-crossing produces a field-dependent fluorescence which has the shape of an inverted Lorentz curve. When the crossing occurs at zero field strength (i.e., for magnetic sublevels of the same angular momentum state) the half width of the Lorentz curve is proportional to $g_j t$ where g_j is the Lande g-factor for the state and t is its lifetime. Experimental studies have been confined to carbon monoxide and argon up to this time.

Optical excitation of low-energy (<1000 eV) ion-atom and ion-molecule collisions has gained increasing interest in the last few years. Such studies are important for gaining insight into fundamental collision theories for heavy particles and for determining the importance of such collisions in the excitation of planetary atmospheres. Preparatory to investigating collisions between ions and atmospheric gases, we have been studying collisions of He^+ ions with helium and argon in order to compare our results with those obtained by other workers and thus to ascertain the consistency of results from different laboratories. We have also extended certain aspects of collisions with argon to include observation of lines from Ar I and He I , as well as those from Ar II which have been reported by other workers.

4. Progress from November 1, 1969 through April 30, 1970: Investigations of CO have been discontinued during this period; they will be resumed after the acquisition of power supplies which will permit sweeping the magnetic field through several kilogauss so that rotational levels with very small g factors may be studied more accurately.

Studies of level crossings in the $(3p^5 4s)^3P_1$ state of argon have been continued and directed toward obtaining more reliable data. The quality of the data has been improved by employing a 2450 mc microwave power source for

the lamp rather than the 30 mc rf source which had been used previously. The resonance line used to excite this state lies at 1067 \AA , the spectral region in which the transmission of lithium fluoride windows begins to decrease rapidly; further improvement in signal-to-noise ratios has been achieved by using windowless lamps. At the present time, we have several measurements between 5×10^{-4} Torr and 10^{-2} Torr. Thus far, no effects of coherence narrowing are observed, and we are in the process of correlating the measurements with available theories.

Studies of low-energy ion-atom collisions have been directed toward the measurement of $\text{He}^+ + \text{He}$ excitation cross sections. Although our results show the same general oscillatory features, as a function of energy, which have been reported by Dworetsky, et al.¹, there also exist significant differences. In particular, our measurements of cross sections exhibit a general increase as a function of bombarding energy in contrast to those of Dworetsky, et al., who indicate that the cross section decreases in most cases from the peaks which occur at energies just above threshold. The resolution of these divergences is important for developing an adequate theory for low-energy collision processes, and this problem will be pursued in the weeks ahead.

5a. Publications and Conference Papers:

1. Wells, W. C. and Isler, R. C., "A Measurement of the Lifetime of the $\text{A}^1\pi$ State of CO by Level-Crossing Spectroscopy," Phys. Rev. Letters, 24, 705 (1970).

2. Isler, R. C. and Nathan, R. D., "Optical Excitation in Low Energy Collisions of He^+ with Ar," Bull. Am. Phys. Soc., 15, 176 (1970).

3. Burnham, R., and Isler, R. C., "Level-Crossing Spectroscopy of the $(3p^5 4s)^3P_1$ State of Argon," Bull. Am. Phys. Soc., 15, 213 (1970).

5b. Degrees Granted:

Wells, W. C., Ph.D.

Title of Dissertation, "Level-Crossing Spectroscopy of Diatomic Molecules: Application to an Excited State of Carbon Monoxide."

6. Expenditures from November 1, 1969 through April 30, 1970:

None: funds are being reserved for summer salaries.

¹S. Dworetsky, R. Novick, W. W. Smith, and N. Tolk, Phys. Rev. Letters, 18, 939 (1967).

PROJECT A38

PARTICIPATION AND EVALUATION OF THE
SCIENTIST-PROFESSOR IN THE NASA PROGRAM

1. Department: Sociology
2. Principal Investigators: E. Wilbur Bock and George A. Watkins
3. Background: Universities have played an important role in the development of science in this country. Although research on campuses is determined to some extent by individual preference on given themes or topics, society has been one of the major propulsors of the direction of scientific development. The NASA program has been one of the most important undertakings, involving not only the space centers but also industries and universities. On the other hand domestic social problems have become so acute that questions have been raised whether or not the total amount of money and talent should be oriented towards the solution of societal problems. However, it is important to know how the individuals involved in the process of developing knowledge react to this debate. The group under study in this investigation is composed of scientist-professors.

Since the scientist on campus, whether or not he is involved in a NASA project, has at least one other role (that of professor) that is theoretically as important as the role of the scientist, such a double role may condition his perception regarding the role of science in society. Another factor which may affect the scientist-professor is the research undertaken under federal sponsorship (i.e., NASA institutional and/or project grants). It has been argued that federal funding of basic research "directs" the research and thus channels the course of basic research in this country. It has also been argued that scientist-professors who have funding from private sources engage in research which better represents their own research interests.

The objectives of this study may be divided into two parts: First, perception of the conflict between the role of scientist and professor; reasons why the scientist-professor decided to engage in a NASA project; the importance of the NASA project in the individual's career; and, the relative importance the scientist-professor gives to the NASA project vis-a-vis applied research for solutions of societal problems. The second major part of this study concerns itself with the implications for the scientist-professor's research and for his social responsibility by his accepting federal funds for basic research.

4. Progress from November 1, 1969 through April 30, 1970: The statistical methods used for the analysis of the first objective of this study have included: (1) descriptive statistics for simple comparisons of characteristics of the three subsamples; (2) factor analysis to determine the major dimensions of role conflict, commitment to science, commitment to societal problems, and job satisfaction; (3) covariance analysis to determine the importance of belonging to one of these subsamples; and (4) regression analysis to determine the factors related to points 1 through 3.

The statistical techniques used in the analyses of the second objective of this study are: (1) the construction of an Ideal Scientific Orientation Scale using Guttman Scalogram Analysis; (2) the construction of a Job Satisfaction Scale using Guttman Scalogram Analysis; (3) the building of an Index of Commitment using the Guttman Technique and using indices indicative of the scientist's actual achievements; (4) use of Mann-Whitney U to test differences for Ideal Scientific Orientation Scores, Job Satisfaction Scores, and Index of Commitment Scores for the three subsamples; and, (5) use of Spearman's rho to test association of these three scores for the total sample and subsamples.

5. Publications: George A. Watkins, a graduate student in sociology, is participating in the project, and his dissertation and several papers will come from this study.

A general report is in progress and will present the major findings of the present research.

An article entitled, "Commitment to Science Among University and Non-University Scientists," is being prepared.

An article entitled, "Religious Attitudes of Scientists in Three Working Situations," is being prepared.

6. Expenditures from November 1, 1969 through April 30, 1970:

Salaries	\$1304.20
Expenses and Services	<u>482.85</u>
Total Expenditures	\$1787.05

PROJECT A41

METABOLIC RESPONSES TO THE STRESS OF OXYGEN AT HIGH PRESSURE

1. Department: Physiology

2. Principal Investigator: Melvin J. Fregly

3. Background: Continuous exposure to pure oxygen at greater than 0.7 atmosphere is fatal to animals within a matter of hours. Although there is a great deal of information regarding the toxicity of continuous exposure, little information is available regarding either the tolerance or the metabolic responses of laboratory animals to intermittent, daily exposures to oxygen at high pressure. Such information could help to establish dose-response relationships between the duration of intermittent exposure to oxygen at high pressure and the physiological and pathological effects resulting from it. Knowledge of this relationship may be applicable to those situations, including radiation therapy, exploration of ocean depths, space exploration etc., where oxygen at high pressure may be used for short intervals of time. The tolerance limit in terms of oxygen pressure and duration of exposure, as well as the effect of such exposures on metabolic activity are the focal points of this research. In addition, a study of cross-adaptation between certain physiological stresses is being undertaken. For example, the possibility that intermittent exposure to oxygen at high pressure might provide cross-tolerance to other stressful situations, e.g. exposure to cold, hypoxia or hypertension, is under study.

4. Progress from November 1, 1969 through April 30, 1970: Two separate but similar experiments were carried out to test some physiological effects of intermittent exposure to oxygen at high pressure. In the first experiment, rats were exposed for 37 days to 1 atmosphere of oxygen for 1/2, 1 or 2 hours daily; while in the second, rats were exposed for 28 days to 2 atmospheres of oxygen for the same daily exposure schedule. In both experiments, individual food and fluid intakes, as well as body weight, were measured daily throughout the experiment. During the last week of the second experiment, the colonic temperature and heart rate of each rat were measured. At the end of each experiment all rats were administered 7 μ c of ^{131}I and killed 24 hours later to assess the state of activity of the thyroid gland. At death, the thyroid gland was removed, weighed and radioactivity measured in a scintillation detector. In addition to the thyroid gland, heart, kidneys and adrenal glands were removed and weighed.

Intermittent exposure to 1 atmosphere of oxygen for 2 hours reduced both food intake and body weight of this group below that of controls, while exposure for either 1/2 or 1 hour had no significant effect. The weight of the adrenal glands appeared to increase in proportion to the increase in time of exposure to oxygen. The weights of heart and kidneys as well as the uptake of ^{131}I by the thyroid gland were unaffected by the treatments.

Thus, the most striking effect of exposure to 1 atmosphere of oxygen occurred in the group exposed longest (2 hours). The effect was a reduction in food intake and body weight gain. The activity of the thyroid gland, as assessed by uptake of ^{131}I , by protein bound iodine concentration and by

thyroid weight, was not affected by exposure to 1 atmosphere of oxygen. Histological analysis of the thyroid gland, heart and kidneys, to be performed, will be used to confirm these conclusions.

Intermittent exposure to 2 atmospheres of oxygen reduced body weight and daily water intake in the groups exposed for either 1 or 2 hours. Mean colonic temperature and heart rate of all treated groups were reduced below that of controls. Exposure to 2 atmospheres of oxygen had no significant effect on heart, adrenal, thyroid or kidney weight ratios for any group. Uptake of ^{131}I by the thyroid glands of all 3 treated groups was depressed by exposure to 2 atmospheres of oxygen. It would thus appear that exposure of rats to 2 atmospheres of oxygen for either 1 or 2 hours daily for 28 days is accompanied by signs of physiological distress. In addition, changes in activity of the thyroid gland, as assessed by uptake of ^{131}I , suggest that secretion of thyroxine may be affected. Histological analysis of the thyroid gland is being made.

Other studies have been carried out to assess the effect of the stress of exposure to cold on water exchange in rats. Dehydration, which accompanies exposure of rats to cold air, is manifested by increases in serum osmolality and chloride concentration and in a thirst following removal from cold. In addition, more urine is excreted for a given water intake by cold-exposed than by control rats. To assess renal concentrating ability, cold-exposed rats were either administered pitressin (antidiuretic hormone, 200mU) or dehydrated for 24 hours. The greater urinary flow rate observed in cold-exposed rats was reduced by each of these treatments, but remained significantly above control level. In addition, urinary flow rate of cold-exposed rats was greater for a given urinary osmolality than was that of controls. Thus, chronically cold-exposed rats do not concentrate their urine to the same extent as controls. The fact that a greater urinary flow rate accompanied both administration of pitressin and dehydration of cold-exposed rats suggests that renal tubular response to antidiuretic hormone is attenuated by cold. However, reduced production of antidiuretic hormone and changes in renal hemodynamics are not excluded by this experiment. The thirst mechanism of cold-exposed rats appears to be intact as judged by spontaneous water intake at either 1 or 2 hours following a 24-hour dehydration. While other tests are necessary, present results suggest that alteration in the relationship between water intake and urinary output observed during exposure to cold is more closely related to renal than to thirst factors. The results of this study have been prepared in manuscript form and will be submitted for publication shortly.

Cross-adaptation between the stress of hypoxia and renal hypertension was studied in rats. Exposure of rats to an atmosphere containing 13% oxygen immediately after induction of hypertension prevented the elevation of systolic blood pressure to the level of hypertensive controls maintained in an atmosphere containing 21% oxygen. The protection afforded remained only as long as the rats were exposed to hypoxia. Following return to 21% oxygen, mean blood pressure of the treated group was identical with that of untreated controls within two and one-half weeks. Paired feeding of the control animals to match their food intake with that of the rats exposed to 13% oxygen assured that the protective effect of hypoxia was not related to an accompanying anorexia. The mechanism responsible for the protection observed is unknown but it may be associated with one or a number of the physiological and biochemical changes induced by hypoxia. A manuscript describing the results of this experiment has been accepted for publication in the Proceedings of the Society for Experimental Biology and Medicine, and will be published in the May 1970 issue.

Cross-adaptation between the stress of hypertension and oxygen at high pressure (2 atmospheres) is under study. Measurements will be made in renal hypertensive rats to determine whether both the rate of elevation of blood pressure and the maximal level attained are influenced by daily exposure to oxygen at high pressure.

5. Publications:

1. Fregly, M. J., Renal concentrating ability of rats exposed to cold, Federation Proceedings 28, 791 (1960).

2. Fregly, M. J., Comments on cross-adaptation, Environmental Research 2:435-441 (1969).

3. Fregly, M. J., Effect of exposure to hypoxia on development and maintenance of renal hypertension in rats, Proc. Soc. Exper. Biol. Med. (in press).

6. Expenditures from November 1, 1969 through April 30, 1970:

Salaries	\$ 268.19
Expense	<u>1533.00</u>
Total Expenditures	\$1801.19

PROJECT A52

CARDIOVASCULAR RESPONSES TO STRESS

1. Department: Psychiatry
2. Principal Investigator: George W. Barnard, M. D.
3. Background: In a previous project we found that the human physiological system is composed of a series of subsystems. These subsystems operate with different rates of physiological lag in response to stress. This means that one subsystem may contain little lag so that one can measure a physiological response which is relatively uncontaminated by previous responses. On the other hand, other physiological subsystems have a high degree of lag and this is carried over to the next response to stress and thereby contaminates the results. In order to quantify the amount of lag, we developed a statistical method for deriving the coefficient of response relevance (CRR).

In the first study this method was applied to the heart rate and systolic blood pressure data obtained from subjects undergoing serial stressors. The results indicated a CRR for heart rate = 0.84 and blood pressure (ear) = 0.25. Our tentative conclusion was that heart rate was highly relevant, with little physiological lag, but blood pressure contained higher levels of lag. Since it was not clear whether the low value obtained for blood pressure was due to an instrumental factor or to a true physiological lag, a more controlled study was performed.

In the second study 50 normal male subjects were exposed to serial stressors with each stress preceded by a rest period and an anticipation period and followed by a recovery period. Altogether there were thirty definable periods. Heart rate was recorded continuously and mean heart rate per minute was obtained on printout. Both systolic and diastolic blood pressures were measured once per minute by standard clinical methods. The data were analyzed, with means and standard deviations being obtained for each period. A correlational analysis for each physiological measure, (heart rate, systolic blood pressure and diastolic blood pressure) was performed for the thirty periods of measurement. Using these data we then derived the coefficient of response relevance for each variable. Prior to analyzing the data we had predicted that heart rate would show much less physiological lag than systolic blood pressure and therefore would earn a higher coefficient of response relevance score. Our predictions were confirmed with heart rate CRR = 0.88 and systolic blood pressure CRR = 0.36. An unexpected finding was diastolic blood pressure CRR = 0.76.

Having demonstrated to our satisfaction that heart rate was relatively free of physiological lag, we sought ways of further defining the internal oscillations for this subsystem. In our earlier work we could not find a commercially available instrument to give mean heart rates per minute in a printed form, so we built our own device. At the same time we began development of a digital beat by beat cardiometer. The beat-by-beat

component was not ready for use in the prior study, so we used our minute counter and printer. Further development on the beat-by-beat cardiometer has been accomplished and we can report on the technical details. Using the mathematical logic of a cardiometer by Major Adolph W. Foeh, Jr., USAF School of Aerospace Medicine, Brooks AFB, Texas, we sought to implement and redesign the digital logic using Signetics and Fairchild integrated circuits. Conceptually, the design consists of a binary counter, a BCD counter, clock and timing logic, and digital logic which generates control pulses dependent on the contents of the binary counter. A cycle of operation which is repeated for each R-R interval is described as follows: Each input heart beat resets the binary counter to a value such that at the end of 300 milliseconds the counter contains the number 200 (300 milliseconds is the length of time corresponding to 200 beats per minute). After the 300 millisecond delay, the binary counter is triggered by clock pulses and counts down. If selected pulses are prevented from triggering the counter, it can be made to count down at a hyperbolic rate and thus maintains step with integer values of heart rate from 200 down to 40 BPM. This is achieved by logic based on the present count in the counter, which functions as a tabulator of the amount of time elapsed since the previous heart beat. The logic generates signals which control the length of time between pulses of the variable-length pulse generator. When the next R wave of the heart beat arrives, the correct rate is contained in the counter. The BCD down counter is slaved to the binary counter and receives pulses only when the binary counter receives pulses. It is also initialized to 200 and counts down in a decimal mode so that when the next R wave arrives, the correct rate is contained in the BCD counter and is gated out to the buffer by a pulse coincident with the next heart beat. This digital cardiometer has a linearity of ± 1 beat in monitoring heart rates from 40 to 200 beats per minute. With this degree of sensitivity and accuracy, we are now in a position to analyze the oscillations of the cardiovascular system in a discriminative manner which was not possible previously.

4. Progress from November 1, 1969 through April 30, 1970: Because of the large amount of data generated from monitoring beat-by-beat heart rate from six individuals in a group setting, computer processing of the data was mandatory. We installed a cable connecting our cardiometers to an IBM 1800 computer but ran into programming problems. After trying this route, we switched to the PDP-8 computer, which has been more satisfactory. Programs have been written and de-bugged to process the data from six subjects simultaneously. Additional programs are currently being written. Each subject's vocalization is being measured and processed along with the heart rate. Since each subject has a small audio receiver, he can receive prompting cues from an observing therapist. In the next phase we plan to record the operant and physiological data on T.V. so that we can correlate the two facets of behavior.

5. Publications and Presentations:

Barnard, G. W. and Garrett, R., "Heart Rate Monitoring in Groups," Scientific exhibit, APA - Miami, Florida, May 4-9, 1969.

6. Expenditures from November 1, 1969 through April 30, 1970:

Expenses	<u>\$38.00</u>
Total Expenditures	\$38.00

PROJECT A53

A MAJOR RADIOASTRONOMICAL ARRAY

1. Department: Astronomy
2. Principal Investigators: A. G. Smith and T. D. Carr
3. Background: The University of Florida Radio Observatory has, for 14 years, made major contributions to knowledge of the decameter-wavelength radio emission from the planet Jupiter. These studies have added a great deal to our understanding of the physical environment of the largest planet in the solar system.¹ Because of the unavailability of suitable tracking antennas of large effective area for low-frequency monitoring, virtually all of the observational work on the Jovian decimetric bursts, both here and elsewhere, has been done with small antennas having effective areas of a few hundred square meters or less. In order to extend the observations to far lower flux levels, we have undertaken the design and construction of a very large phase-steered antenna array to operate at a frequency of 26.3 MHz. The array consists of 640 half-wave dipoles over a ground plane, covering a capture area of $3 \times 10^4 \text{ m}^2$, or nearly 8 acres, about half the size of the Arecibo dish.

The rigid self-supporting dipoles are mounted on rotating masts, so that the polarization of all or part of the array can be changed at will. The $2.2^\circ \times 5.6^\circ$ beam will be easily steerable over a 50° arc through a system of remotely controlled Butler matrices operated from the observer's console. Steering beyond this range can be achieved by manually inserting cables in the transmission lines. Multiple beam operation will also be provided for. The design has benefitted from consultation with Professor William Erickson of the University of Maryland, Professor George Swenson of the University of Illinois, and Dr. C. H. Costain of the Dominion Radioastrophysical Observatory.

It is anticipated that the complete antenna, in addition to greatly extending the Jupiter observations, will be used in investigations of flare stars carried on in collaboration with simultaneous optical monitoring at the University's Rosemary Hill Observatory. It will further be used for observations of pulsars, as well as for planets other than Jupiter (Saturn, for example, is suspected of being a source of low-level decametric emission²).

¹ For a review of these studies, see Radio Exploration of the Planetary System by A. G. Smith and T. D. Carr (D. Van Nostrand Co., Princeton N. J., 1964); and also "Jupiter, the Radio-Active Planet," by A. G. Smith, American Scientist **57**, 177 (1969).

² See Smith, A. G., et al., Astrophys. J. **141**, 457 (1965).

4. Progress from November 1, 1969 through April 30, 1970: Excellent progress can be reported for this period. Erection of the dipoles is substantially complete, and one major section of the array has been put into operation on a test basis. A photograph of a portion of the array, as of May, 1970, is shown on the following page. A number of excellent drift curves of Cygnus A have been obtained, indicating that the array is functioning exactly in accord with design specifications. The prototype of the Butler matrices has been completed and is undergoing evaluation (8 more of these rather complex circuits must be fabricated). The following table indicates the status of each of the several projects which must converge to complete the array:

	<u>% Completed</u>
Preparation of site	100
Procurement of material, electronic components, and equipment	90
Laying of 90 miles of ground plane wire	100
Fabrication and erection of 640 dipoles and masts	90
Fabrication of 560 hybrid rings, 640 baluns, and 990 phasing cable lengths	80
Fabrication of 640 matching networks	10
Construction and erection of 410 weatherproof boxes	30
Construction of 9 Butler matrices with relay banks	11
Burying of underground conduit and installation of above-ground cable racks	15
Interconnecting of dipoles, boxes, Butler matrices, relays, and observatory building	10
Construction of phase-checking system	80
Modification of receivers	20
Installation of observatory terminal facilities	10

It is estimated that about one year will be required to complete all of the details and produce a fully operable radio telescope. On-site supervision of the construction is being provided by Sr. Jorge Levy, a skilled Chilean antenna engineer who was brought to this country for this purpose. Sr. Levy's salary represents the primary expenditure from the project budget, materials and other expenses being paid for by the University from an NSF Science Development Grant. Application is being made to NSF for funds to pay the final year of this salary after the October 31 expiration of the NASA grant.

5. Publications: The nature of a developmental project such as this is such that it will, of course, produce publishable results only when it is completed. When the array goes into full operation, there is little doubt that it will produce a continuing output of significant scientific results, since it will be one of the world's major decametric antennas.

6. Expenditures from November 1, 1969 through April 30, 1970:

Salaries	\$4,994.00
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SUMMARY OF PUBLICATIONS DURING THE REPORT PERIOD

November 1, 1969 - April 30, 1970

A. Papers Published in Journals

- Project A23: Zelac, R. E. and Cromroy, H. L., "Variation of Rat Radio-sensitivity with Increased Oxygen Partial Pressure of Inspired Gas." *Health Physics* 18, 277-231, 1970.
- Project A24: Herron, W. L., Riegel, B. W., Myers, O. E., and Rubin, M. L., "Retinal Dystrophy in the Rat - a Pigment Epithelial Disease," *Invest. Ophth.* 8, 595 (1969).
- Project A34: Dufty, J. W., "Charge Density Fluctuations in Spectral Line Broadening," *Phys. Rev.* 187, 305 (1969).
- Project A35: Wells, W. C. and Isler, R. C., "A Measurement of the Lifetime of the $A^1\pi$ State of CO by Level-Crossing Spectroscopy," *Phys. Rev. Letters* 24, 705 (1970).
- Project A41: Fregly, M. J., "Renal Concentrating Ability of Rats Exposed to Cold," *Federation Proceedings* 28, 791 (1969).
- Fregly, M. J., "Comments on Cross-Adaption," *Environmental Research* 2:435-441 (1969).

B. Journal Papers Submitted or in Press

- Project A06: "The Electromagnetic Field in the Electrodeless Discharge," submitted for publication.
- Project A27: Colgate, S. O. and Imeson, T. C., "Scattering of Low Velocity Neutral Particles: The Cs - He, Cs - Kr, and Cs - Xe Interactions," *J. Chem. Phys.*, in press.
- Project A30: Myers, G. H., Easley, W. J., and Zilles, B. A., "E.S.R. Spectra of NO₂ in Inert Matrices," *J. Chem. Phys.* 53, No. 3 (in press) (1970).
- Myers, G. H. and O'Brien, R. J., Jr., "Quenching of O₂ ($b^1\Sigma_g^+$)," *Ann. N.Y. Acad. Sci.*, in press (1970).
- Project A34: Dufty, J. W., "Ion Motion in Plasma Line Broadening," *Phys. Rev.* (in press).
- Project A41: Fregly, M. J., "Effect of Exposure to Hypoxia on Development and Maintenance of Renal Hypertension in Rats," *Proc. Soc. Exper. Biol. Med.* (in press).

C. Papers Presented at Scientific Meetings

- Project A19: "Study of Eclipsing Binary Stars Using the Jacobian Integral," Thirty-fourth Annual Meeting of the Florida Academy of Sciences, March 6, 1970.

Chen, Kwan-Yu and Nibondh Saibejra, "The Main Sequence Eclipsing Binaries and the Restricted Problem of Three Bodies," Bull. Am. Phys. Soc. 11, 15 202 (1970).

Project A23: Soler, J. A., Noyes, W. D., Cromroy, H. L., and Richard, G. A., "The Contribution of Relative Renal Mass to Erythropoietin Production," May 2, 1970, Special Sessions of the American Pediatric Society/Society for Pediatric Research, Atlantic City, N. J.

Project A28: Donovan, F. F., Jr., Carr, T. D., and Omer, G. C., Jr., "Radio Mapping of the Hercules Cluster of Galaxies," Bull. Astron. Soc., 2, 190 (1970).

LaForce, C. F., "The Cluster of Galaxies Abell 2256," Bull. Am. Phys. Soc., 11 15, 202 (1970).

Davis, R. W., "Data Reduction for Clusters of Galaxies," Bull. Am. Phys. Soc., 11 15, 202 (1970).

Donivan, F. F., Jr., Carr, T. D., and Omer, G. C., Jr., "Radio Mapping of the Hercules Cluster of Galaxies," Bull. Am. Phys. Soc., 11 15, 203 (1970).

Project 29: Brunsvold, Ronald S., "The Design and Construction of a Platinum Film Velocity Gage," M.S. Thesis, University of Florida, December 1969, A.I.A.A. Student Papers Competition, Atlanta, April 23, 1970.

Project A30: Myers, G. H. and O'Brien, R. J., "Quenching of O_2^* ," Paper PHYS-22, 158th ACS Meeting, September 1969.

Myers, G. H. and O'Brien, R. J., "Quenching of $O_2(b^1\Sigma_g^+)$ " International Conference on Singlet Molecular Oxygen and Its Role in Environmental Sciences," October 1969.

Myers, G. H., "Fluorescence Quenching and Spectroscopy of NO_2 ," Invited Paper, 3M Photochemistry Symposium, May 1970.

Project A34: Lee, R. W., Dufty, J. W., Hooper, C. F., Jr., "A Green's Function Technique for Line Broadening in Plasmas," Bull. Am. Phys. Soc., 15, 170 (1970).

O'Brien, J. T. and Hooper, C. F., Jr., "Electric Micro-field Distributions in a Plasma of Singly and Doubly Charged Ions," Bull. Am. Phys. Soc., 15, 171 (1970).

Project A35: Isler, R. C. and Nathan, R. D., "Optical Excitation in Low Energy Collisions of He^+ with Ar," Bull. Am. Phys. Soc. 15, 176 (1970).

Burnham, R. and Isler, R. C., "Level-Crossing Spectroscopy of the $(3p^5 4s)^3 P_1$ State of Argon," Bull. Am. Phys. Soc., 15, 213 (1970).